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THE MOSQUITOES OF THE HANTS–SURREY BORDER (BLACKWATER VALLEY REGION)

By E. W. Classey, F.R.E.S.

With One Text-figure.

This paper is an account of collections and observations made over the period January 1941–December 1942. Continued observations up to September 1944 have revealed no further species and little new data other than slight variations in emergence dates.

The area concerned is bounded roughly by the River Blackwater on the West, by the Basingstoke Canal on the North, and on the South and East by a line running approximately from Brookwood to Wanborough, and from thence to a point slightly West of the place where the Canal crosses the River at Ash Vale (see fig. 1).

For some of the information concerning the period June to September 1941, I am indebted to Major T. T. Macan, R.A.M.C. I wish also to express indebtedness to Colonel R. A. Mansell, O.B.E., and to Major A. W. McKenny Hughes, R.A.M.C., for their kind assistance and interest, and to Colonel E. B. Allnutt, C.B.E., M.C., for permission to carry out and publish this survey.

In this survey three collecting methods were used : (1) collecting larvae, (2) collecting resting adults and (3) exposing various parts of the body and collecting the females which came to bite. The first method was by far the most remunerative, the only species which were not taken by this method being *Culex molestus* Forskål and *Taeniorhynchus richiardii* Ficalbi, both of which were taken by the third method.

The identification and nomenclature are taken from *The British Mosquitoes* by J. F. Marshall, British Museum (Natural History) 1938.

Anopheles maculipennis Meigen.

Larvae occur throughout the summer months in large numbers in those regions of the Basingstoke Canal and its " flashes " where the surface of the water is covered with *Potamogeton natans* or *Lemna trisulca*. The canal, except in some pools and marshy areas almost completely isolated from the main water, harboured no other species of mosquito larvae. Besides the Basingstoke Canal, the only other stretch of water in which larvae of this species were found was the River Blackwater. Here it was of interest to note that the larvae were absent from the immediate vicinity of the War Dept. Sewage Works outfall, where larvae of *Culex pipiens* Linnaeus were most abundant, and that they gradually became more numerous in lower, and presumably purer, reaches of the river; nowhere did they appear to be so common as in the Basingstoke Canal. Major Macan obtained no records of this species biting during 1941 and was therefore inclined to the view that only the var. *messaea* was present. During the summer of 1942, however, five records were obtained of this species biting man; three at Mytchett and two at S. Farnborough. In the light of these records the possibility of the presence of var. *atroparvus* cannot be ruled out.

Anopheles claviger Meigen.

This species is found all over the area in suitable spots. Larvae are common in the less polluted ditches of the Blackwater Valley and in roadside ditches and small grassy pools everywhere, and also (somewhat surprisingly) in a fairly open lake at Furze Hill, Brookwood. Though fairly common, it was not often found biting man. In the laboratory larvae taken 31.iii.1942 started to pupate 17.iv.1942 and the first adult emerged 20.iv.1942.

Anopheles plumbeus Stephens.

This species was not found by Major Macan in 1941, but on 8.iv.1942 numerous larvae were found in a large rot-hole in a beech tree by the side of the Pirbright road at Mytchett. Subsequently larvae were found in many rot-holes in this district, both in beech and birch. Over 80 larvae were obtained in September 1942 from the tree in which the first specimens were found. One specimen was taken biting 5.ix.1942. In the laboratory, from larvae taken 8.iv.1942, the first pupa was obtained 19.iv.1942, and the first adult 26.iv.1942. The species is also present in horse-chestnut trees by Wanborough Station.

Aedes cinereus Meigen.

Though fairly common, this species is somewhat local in the area, being particularly attached to more or less waterlogged land, where larvae occur in small pools and hollows lined with *Sphagnum* moss. It is present in many localities bordering the Basingstoke Canal, especially in marshy areas at the edge of " flashes " in the canal and also in the Blackwater Valley. It is a very persistent biter. At Great Bottom Flash and from a woodland pool near Mytchett Lake single larvae were taken in September 1941; these are unusually late records, for Marshall records larvae of this species only during the months of April, May and June. Larvae found 17.iv.1942 started to pupate in the laboratory 27.iv.1942 and the first adult emerged 2.v.1942.

Aedes geniculatus Olivier.

This species was not recorded by Major Macan in 1941. In April 1942 a search was made for larvae, and the species was found to be common throughout the area wherever there are suitable rot-holes in trees, both in the Blackwater Valley and on the Bagshot Sands. Larvae also occur in rot-holes in horse-chestnut at Wanborough. In a large rot-hole in a beech tree on the Pirbright road (see *A. plumbeus* above) larvae of this species and of *A. plumbeus* occurred in abundance. Where common, this species is a troublesome biter. Larvae taken 4.iv.1942 and kept in the laboratory started to pupate 19.iv.1942; the first adult emerged 1.v.1942.

Aedes rusticus Rossi.

This generally common species appears to be local in the area. It was not recorded by Major Macan in 1941. One larva, which subsequently died, was obtained in December 1941 at Deadbrook Farm (Hampshire side of the R. Blackwater immediately S. of the Basingstoke Canal) and another was taken by Lt. P. F. Mattingly, R.A.M.C., 16.iii.1942, at Coleford Bridge (Surrey side of R. Blackwater). A long search for this species was made in the spring of 1942 and eventually (12.v.1942) larvae were discovered in plenty at the extreme N.W. corner of Whitegate Copse, Ash Green. They were in a shallow pool

formed by a ditch which had dried up for most of its length, leaving a small patch of water about 12 ft. long and 3–4 ft. wide, densely shaded by low hawthorn bushes. The species bites readily but is not troublesome, owing to its restricted range in the area. In the laboratory larvae obtained 12.v.1942 started to pupate the same day and the first adult emerged 17.v.1942.

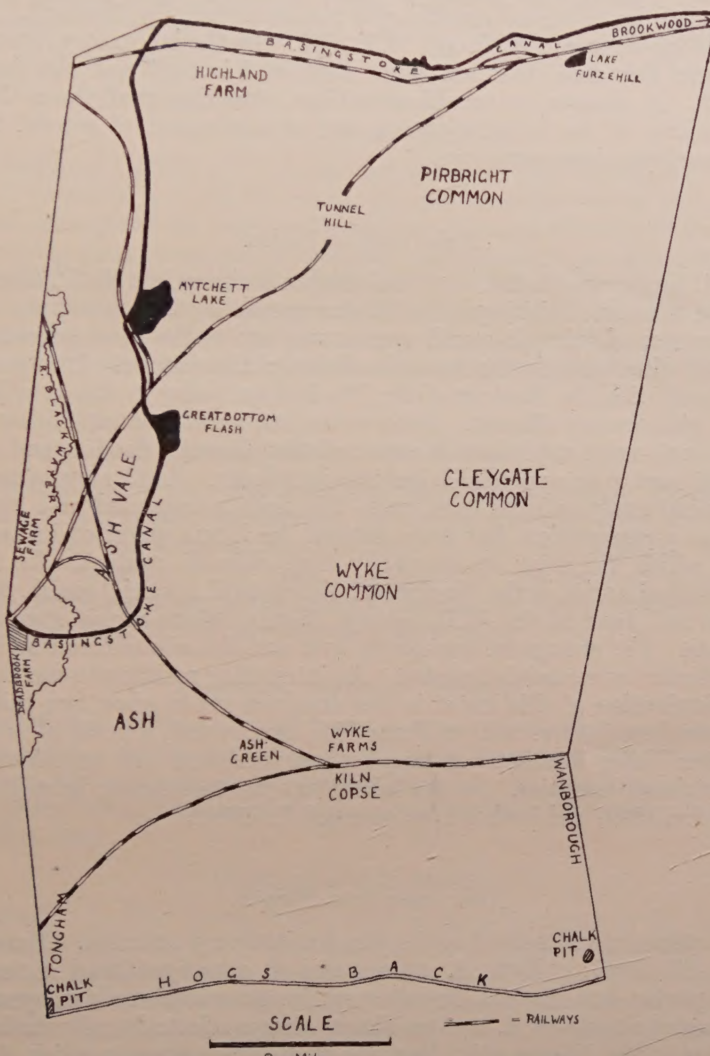

FIG. 1.—Area of mosquito survey on the Hants–Surrey border.

Aedes punctor Kirby.

This species is typical of sandy and gravelly soils and, as was to be expected, proved to be one of the commonest species in the district. Larvae are abundant in temporary pools on the Bagshot Sands and in temporary ditches in the Blackwater Valley. The life history of this species was rather unusual in the summer of 1941. When Major Macan started observations at the beginning of

June both adults and larvae were abundant. The breeding-places (on the Bagshot Sands) dried up, probably towards the end of June, though they were not actually visited till the middle of July, by which time they were quite dry. The pools filled up again during August and larvae appeared. Full-grown larvae collected and kept in the laboratory emerged as adults during the second week of September. Shortly afterwards the pools dried up again. This is another unusually late larval record according to the data given by Marshall. In 1942 first-instar larvae were first found 13.iii.1942. In the laboratory, from larvae collected on this date, the first pupa resulted 2.iv.1942 and the first adult 30.iv.1942. *A. punctor* is a troublesome biter, attacking at all times of the day in the vicinity of its breeding-places and at a distance of several hundred yards from them about sundown.

Aedes caspius Pallas.

In 1941 larvae were taken in several ditches draining into the R. Blackwater, and adults were caught biting in the Blackwater Valley throughout the summer. The occurrence of this salt-marsh species was one of the most interesting and unexpected discoveries in the mosquito fauna of the district. It is possibly to be correlated with the flooding of the Blackwater Valley in this area by water polluted with sewage effluent. Such water has a salt content higher than is usual for fresh water and it is to be expected that alternate flooding and evaporation would lead to an appreciable increase in salinity. Until more observations and chemical analyses have been made this must be regarded as a hypothesis and not as a explanation, but some support for it was provided by two water analyses which did show an unusually high chloride content. In 1942 the species escaped notice in the Blackwater Valley until a special search was made for it on 3rd June at the W.D. Sewage Works, where pupae were found in abundance. The emergence was partly over and the adults resultant from the pupae collected were mainly females. An interesting addition to the knowledge of the distribution of this insect in the area was made when two third-instar larvae were found (19.v.1942) at Furze Hill, Brookwood, several miles from the Blackwater Valley locality. *A. caspius* is a persistent and troublesome biter in its restricted localities. In the laboratory the two larvae from Furze Hill pupated 1.vi.1942, and both adults emerged 7.vi.1942.

Aedes annulipes Meigen.

This species is widespread in the area but not very common. Marshall (pp. 201 and 202) says: "Both *A. cantans* and *A. annulipes* breed in temporary, non-salt pools; but whereas the latter species generally breeds in open, or only partly shaded situations *A. cantans* almost always selects densely shaded ones" —"Owing to the difference in character of the environments which *A. cantans* and *A. annulipes* respectively select, these two species are never found breeding together." In the area under discussion this does not hold good, for larvae of the two species were frequently found together, often with those of *A. punctor* and usually in densely shaded situations. Adults too were often taken in the same situations and at the same times. *A. annulipes* is a vicious biter and is troublesome near its breeding-places. In the laboratory first-instar larvae obtained 13.iii.1942 started to pupate 19.iv.1942. The first adult emerged 26.iv.1942.

Aedes cantans Meigen.

This species occurs throughout the area but breeds most commonly in temporary woodland pools near the Basingstoke Canal. In 1941 the life history was similar to that of *A. punctor*, with which species it was usually associated; larvae were found in June and again in September after the breeding-places had been filled by the rains of August. This is another troublesome biter in the neighbourhood of its breeding-places. In the laboratory first-instar larvae obtained 13.iii.1942 started to pupate 1.iv.1942, and the first adult emerged 7.iv.1942.

Theobaldia annulata Schrank.

Both larvae and adults of *C. pipiens* and this species are often taken together, though *T. annulata* is much less numerous and appears later in the summer. It is found throughout the area, and larvae are common throughout the winter. An interesting gynandromorphic specimen was captured at Mytchett and a description of this specimen was published in 1942 (*Entomologist* **75**: 181). Though females were caught biting both indoors and out, the species was never numerous enough to constitute a nuisance. In the laboratory, from larvae obtained 20.iii.1942, the first pupa resulted 2.iv.1942, and the first adult 10.iv.1942.

Theobaldia fumipennis Stephens.

This species has a very restricted distribution in the area. Seven larvae were found at Furze Hill, Brookwood, 19.v.1942, and four more at the same place 28.v.1942. All these larvae were found in one small artificial pit about 2′ 6″ long × 1′ 6″ wide × 1′ 6″ deep. In spite of a long and careful search no larvae were found elsewhere in the locality, though there are apparently suitable pools a few feet from the pit in which they were found.

Theobaldia morsitans Theobald.

This species is widespread and fairly common in the larval state, though never abundant. It was not taken in the adult stage but larvae were found fairly commonly throughout the winter months. In the laboratory, from larvae collected 20.iii.1942 the first pupa was obtained 1.iv.1942; first adult emerged 8.iv.1942.

Culex pipiens Linnaeus.

Abundant. In 1941 larvae were found in great numbers in the irrigation channels of the W.D. Sewage Works, and from these channels they were washed down into the R. Blackwater. Just below the point where the sewage outfall joined the river the larvae were held up by the leaves of *Potamogeton natans*, and dipping with a dish showed that the population was of the order of 2500 larvae per 100 sq. inches. A few hundred yards lower down the population was much less dense but even as far as three miles downstream, measured in a direct line, a dip with the standard dish in a sheltered bay yielded 165 larvae. It was evident that larvae were being washed downstream, particularly in times of flood, and it was impossible to assess how far the population of the river was due to larvae and egg rafts being washed out of the sewage works and how far it was due to oviposition in the Blackwater itself. It seemed fairly likely, however, that there was some oviposition in the river. Running water is, of course, a most unusual habitat for Culicine larvae. After the weeds were dragged from

the river towards the end of the summer the number of larvae was very considerably reduced. Larvae of this species are to be found throughout the summer in nearly all small pools in the area but are absent from larger bodies of water such as the Basingstoke Canal. Vast numbers of adult females are to be found indoors in the late summer months, with a few specimens of *A. maculipennis* and *T. annulata.*

Culex molestus Forskål.

During the summer of 1942 two specimens which, on examination, appeared to be *C. pipiens*, but which are probably ascribable to this species, were taken by Lieut. Mattingly : one at Aldershot on 21st June whilst biting, and another at Mytchett on 5th July in a bedroom. The latter specimen had its abdomen distended with blood which, on examination, proved to be mammalian.

Orthopodomyia pulchripalpis Rondani.

A single larva of this species was found under peculiar circumstances near Brookwood in December 1941. A full account of this occurrence is given in 1942, *J. R. Army med. Cps* **78** : 144.

Taeniorhynchus richiardii Ficalbi.

It is difficult to ascertain the distribution of this species in the area as the larvae and pupae cannot be collected by ordinary means, since both obtain oxygen by piercing submerged vegetation, not by rising to the surface of the water like other CULICIDAE. As no larvae or pupae were obtained, despite a very long and close search, the only means of obtaining the species was by collecting specimens biting man in the open. By this means two specimens were obtained, both from the same locality ; one 31.vi.1942 and the other 1.viii.1942 in a dense wood on the N. bank of the Basingstoke Canal near Brookwood.

SOME GENERAL REMARKS ON SUB-SOCIAL BEETLES, WITH NOTES ON THE BIOLOGY OF THE STAPHYLINID, *PLATYSTETHUS ARENARIUS* (FOURCROY)

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With 15 Text-figures.

I. Some General Remarks on Sub-social Beetles.

Beetles are perhaps the most numerous natural order in the animal kingdom and occupy nearly all terrestrial and freshwater environments known to support life, but they show a nearly complete absence of social organisation despite their otherwise remarkable diversity of habits. Only in eight [1] families are species known which exhibit a sub-social type of behaviour. To these eight families may now be added a ninth, the Staphylinidae, as shown by the observations recorded below on *Platystethus arenarius* (Fourcroy). A list of these nine families is as follows :—

1. Staphylinidae (*Platystethus arenarius* (Four.)).
2. Silphidae (*Necrophorus* spp.).
3. Hydrophilidae (*Spercheus* spp., *Epimetopus* spp., *Helochares* spp.).
4. Scarabaeidae (*Copris hispanus* (L.), *C. lunaris* (L.)).
5. Passalidae (*Passalus* and other genera).[2]
6. Tenebrionidae (*Phrenapates bennetti* Kirby).[3]
7. Chrysomelidae (*Omaspides pallidipennis* Boh., *Pseudomesomphalia thalassina* (Boh.), *Selenis spinifex* (L.), and possibly *Phytodecta rufipes* (F.)).[4]
8. Scolytidae (Xyloterini, Xyleborini).
9. Platypodidae (probably all).

[1] Two species of the family Silvanidae, *Coccidotrophus socialis* Schw. & Barb. and *Eunausibius wheeleri* Schw. & Barb. which live in the hollow leaf-petioles of *Tachigalia paniculata* Aublet in British Guiana, are included amongst the social beetles by Wheeler (1921). However, it is difficult to see how these species can be regarded as social. They are gregarious as, for instance, are the species of *Laemophloeus* infesting stored products or those of *Silvanus* found under bark. Wheeler himself points out (*op. cit.* : 103) that the adults and larvae, ". . . seem to be very indifferent to one another," and his description of the indiscriminate butting that goes on between larvae and adults when one or both stages are competing for secretions of honey-due from the *Pseudococcus* is clear evidence of an active hostility between them at such times. The fact that this butting is not carried to the extent of maiming one another cannot be produced as evidence of a lack of hostility. The adult beetles guard the entrance of the petiolar cavity, and this fact would be sufficient, I think, to include them with the social beetles if it could be shown that they do so at least partly in order to protect their young, but within the cavity their behaviour towards their young—ranging from complete indifference to active hostility—makes it appear probable that this defence instinct concerns only the individual guarding the nest.

[2] The observations of Ohaus (1899–1900, 1909) and Wheeler (1921, 1923) on the social habits of *Passalus* and allied genera require confirmation in view of the more critical experiments of Heymons (1929), who found that neither *Passalus interstitialis* Eschscholtz nor *Paxillus recticarinatus* Klug had sub-social habits.

[3] Before *Phrenapates bennetti* can be accepted as a sub-social beetle, the work of Ohaus (1899–1900, 1909) must be confirmed.

[4] Von Lengerken's account (1939) of the care of the larvae by the female of this beetle is most unconvincing.

By social or sub-social beetles is meant those in which the parents care for the eggs or both the eggs and other immature stages. Many beetles make a more or less elaborate cell, case, or cocoon to protect the eggs, but once the eggs have been laid or embedded in the larval food material, the parent beetle leaves the site and severs all connection with them. Such beetles are not here considered to be sub-social nor are those which do no more than provide stores of food for the larvae at the time the eggs are laid.

It has already been pointed out by Wheeler (1928) that amongst insects may be found nearly every transition in the relationship of parents to young from almost complete indifference to one of mutual and lasting co-operation. The following series, somewhat modified from Wheeler (1928 : 12), will serve to make this clear.

1. The female oviposits in the general environment in which it lives, and the eggs may or may not happen to be laid on food suitable for the larvae (*e.g.*, some *Sitones*).

2. The female oviposits on or near the larval food material. Most beetles do this, but in some the instinct to do so is not at all fixed, and it is then often difficult or impossible to distinguish them from " 1 ".

3. The female supplies the egg with a protective covering which may be of excrement, as in the Camptostomata among the Chrysomelidae, and the egg may be laid at random or on the larval food.

4. The female oviposits only in a specially prepared nest which may be a simple cavity in the soil or an elaborate case or cocoon and (a) a supply of larval food is not left in the nest (e.g. *Hydrophilus*), or (b) a supply of food, easily accessible to the young larvae (mass provisioning), is left in the nest (e.g. *Bledius*). In these cases the male often co-operates with the female in making the nest or provisioning it or both (*Geotrupes*, *Lethrus*, etc.).

5. The female, or both the female and male, remain with the eggs or young larvae and care for them (*Platystethus*, *Spercheus*, *Omaspides*, etc.). The parents do not feed the larvae, but food for this stage may have been stored in the nest at the time of egg-laying (*Copris*) or the nest may be made in the food material (*Platystethus*).

6. The female, or both the female and male, remain with the eggs and larvae and feed the latter with specially grown or prepared food (progressive provisioning) and (a) the larvae may be fed only at certain critical times—immediately after hatching and immediately after each moult—as in *Necrophorus* spp., or (b) the larvae may be fed continuously as in the Xyleborini.

There are no known beetles that have a social organisation as highly developed as that found among some termites and aculeate Hymenoptera, *i.e.* where : " The progeny are not only protected and fed by the mother, but eventually co-operate with her in rearing additional broods of young, so that parent and offspring live together in an annual or perennial society."

Beetles that apparently make no provision whatever for their progeny, or, to use an anthropomorphism, show a complete indifference to the fate of their eggs and larvae, are included in the first category listed above. Those which make some provision for their progeny, even if it be only to place the eggs near or on the larval food, are included in " 2 " to " 4 " ; and these may be described as infra-social. Those that in some way protect or tend the eggs or young larvae after the eggs have been laid, or stores of food provided for the larvae, are placed in " 5 " and " 6 " ; and these may be described as sub-social. What is common to the first four categories is a lack of intimacy between

parents and eggs after the eggs have been laid or enclosed, whereas this factor of intimacy, necessarily involving propinquity, is common to " 5 " and " 6 ".

The six categories listed above help to make it possible to understand more readily the varied relationships that exist between parents and progeny in beetles. Though in a broad general way they represent an evolutionary series of increasing complexity manifesting new and unexpected properties at each stage, it must not be thought that all beetles here considered to be sub-social have necessarily gone through stages " 1 " to " 4 ". While it is conceivable that some of the CHRYSOMELIDAE, e.g. *Omaspides pallidipennis* Boh. (or at any rate its direct ancestors), have gone through all previous stages, this is most emphatically not the case with the majority, sub-social habits having been obviously evolved independently in unrelated families.

These six categories are not always mutually exclusive. They represent no more than an attempt to show in a simple one-dimensional manner what appear to be the nodal points in the complex and very diversely interconnected behaviour of beetles. For example, " 3 " may well be considered to be no more than a special case of " 4 ", the chief difference between them being that in " 3 " the female is usually only concerned with one egg at a time, whereas in " 4 " she is concerned with making a cocoon or case to contain two or more eggs. However, the leaf-rolling weevils of the genus *Attelabus* would be placed in " 4 ", although some species lay only one egg in each of their complicated leaf-funnels.

II. NOTES ON THE BIOLOGY OF *PLATYSTETHUS ARENARIUS* (FOURCROY).

The habits of most of the British STAPHYLINIDAE are scarcely known. While it is undoubtedly true to say that the majority of the species of the family are predacious, notable exceptions occur in the tribe Oxytelini and in the subfamily OXYPORINAE. The algal feeding habits of various species of *Bledius* and the phytophagous and coprophagous habits of species of *Oxytelus* are slowly becoming known. Others, for instance *Oxyporus rufus* (L.), apparently feed exclusively on fungi.

The slow-moving and non-predacious Oxytelini are almost certainly the most primitive representatives of the family in our fauna. *Platystethus* belongs in the tribe Oxytelini, and the notes recorded below may be of some slight assistance to students of phylogeny in addition to making known a fascinating and very unusual type of sub-social organisation amongst beetles.

P. arenarius is widely distributed in Europe, and it is one of the most common of the British Staphylinids found in cow dung. The account of its life-history and habits given here is based on field observations made during September and October 1944 at Linton, Cambridgeshire, and on breeding experiments in an incubator kept at 25° C. ± 0·50 with a relative humidity of 70–75%. While this account of its biology is patently incomplete, it is nevertheless felt that the main features have been described; further details can be filled in by those interested. The beetle is abundant in the field, easy to handle, and its food—cow dung—is available in large amounts.

Cultures were maintained in petri dishes and in two types of observation cages. No. 1 consisted of a piece of cardboard 2 mm. thick with its centre cut out to form a square of 57 × 57 mm. This card was held by paper clips between two glass plates. Many larvae and several adults were satisfactorily kept in the cow dung with which it was filled. It had the disadvantage that the top and

bottom of the brood chambers were stuck to the glass, so that it could not be opened without damaging them. To overcome this difficulty No. 2 was made. No. 2 was similar but smaller and held between two glass microscope slides. A thin cover-glass was put over the brood chamber (fig. 15) so that the cage could be opened without disturbing the female. Only one female was put in each No. 2 cage.

1. *Oviposition and eclosion of the eggs.*

Before the eggs are laid the female excavates a broadly oval to nearly spherical chamber 6–10 mm. in its greatest diameter. Altogether about 30

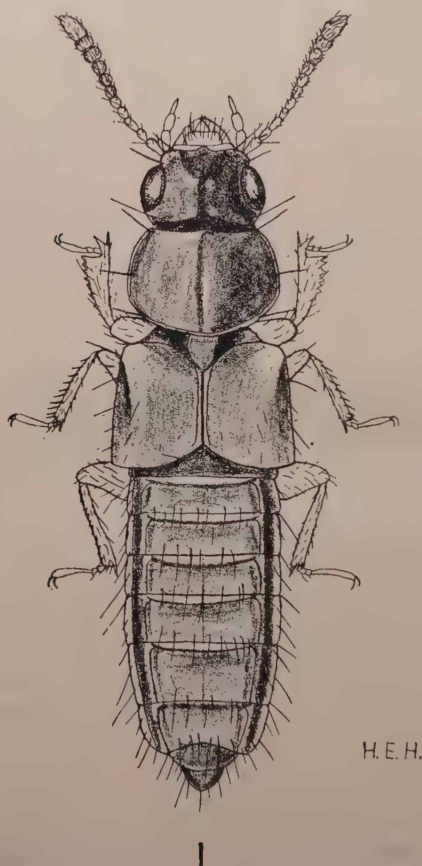


FIG. 1.—*Platystethus arenarius* (Fourcroy).

of these chambers containing eggs and females were found in the field during the mornings of the 3rd, 10th, and 17th of September. Most of these egg chambers were made in cow-pats one-fourth of an inch to one inch above ground level, but several of them were found at the bottom of cow-pats so that part of the chamber was in the earth and only part in the dung. No egg chambers were found entirely in the earth beneath the cow-pats. Egg chambers made in dung in petri dishes were similar in shape to those found in the field, but those made between

the glass slides of the observation cages differed in having a flat roof and a flat floor although they were roughly circular in outline. The floors and roofs of these were seldom more than very imperfectly lined with dung. Six batches of eggs collected in the field were found to contain 64, 90, 43, 47, 80, and 93 eggs respectively. An error of at least 5% should be allowed here, as the eggs are often so firmly stuck to each other that in separating them for counting an undetermined number were broken in each case. In the laboratory, three females laid batches of eggs containing 20, 30–40, and 55–60 eggs respectively. Four other females laid batches which were estimated on size to contain less than 40 eggs each. It is possible that the smaller average number of eggs laid in the laboratory is due to the females having already laid some eggs in the field, or to their being continually disturbed, or to the much more restricted environment, or to being kept at much higher temperatures than obtained in the field, or to a combination of two or more of these factors.

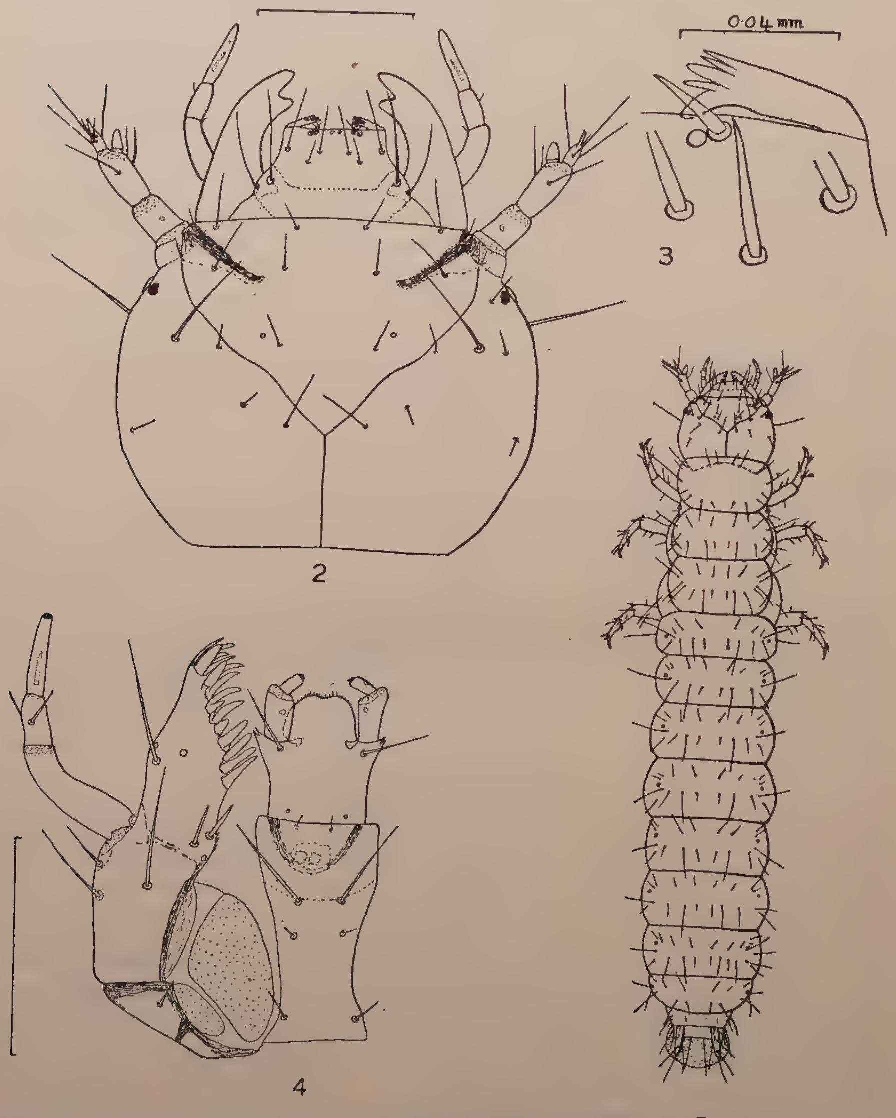
The batch in each chamber is usually found very near or actually touching one of the walls, but batches are occasionally found in the middle of the floor. The eggs are usually stacked in three or four layers, and the long axis of each egg is usually vertical, but there is here considerable variation and some eggs may be lying on their sides. All of the batches laid in the laboratory were much more irregularly stacked than those found in the field, and some showed no signs whatever of being arranged in a definite manner. Although many hours were spent watching pregnant females with greatly swollen abdomens, oviposition was never observed. It appears that the eggs are stacked as they are laid and not laid loosely and subsequently stacked. The evidence for this is (1) the eggs are usually stuck together, often very firmly so, and (2) several eggs of three different females were separated from their respective stacks with the aid of two pins and scattered on the floor of the chamber, and, though in each case the female continued to guard them, she made no attempt to add them to the part of the stack left intact but simply allowed them to lie on the floor where they had been left by me.

In the field no males were found in chambers containing eggs. On two occasions a male and female were found together in a chamber, but I do not know if the female later laid eggs in these particular chambers. It is, however, certain that the male does not normally help the female to guard the eggs, and, from incomplete field observations, it appears probable that after copulation the female leaves the male, so that the male takes no part in constructing the egg chamber, as is the case with some of the coprophagous SCARABAEIDAE.

The incubation period of the eggs is four to five days. The eggs of each batch do not hatch simultaneously, but the last usually hatched within one to four days of the first. This was true of both those brought in from the field and those laid in the laboratory. This prolonged hatching period was undoubtedly even more prolonged in the field in this September of cold unsettled weather. The fact that there can be up to four days' difference between the first and last hatched eggs of a single batch seems to be sufficient evidence for believing that the female does not lay all the eggs of a batch at one time but rather over a long period. This period varies according to temperature and number of eggs laid, and it must correspond in time for each batch to the difference in time between the eclosion of the first and last eggs. This difference in time between the hatching of the first and last eggs is stressed here because it is of considerable biological significance, as will be shown later.

The process of eclosion or hatching from the egg is most interesting. Sometime before eclosion the main tracheal branches of the larva are filled with air,

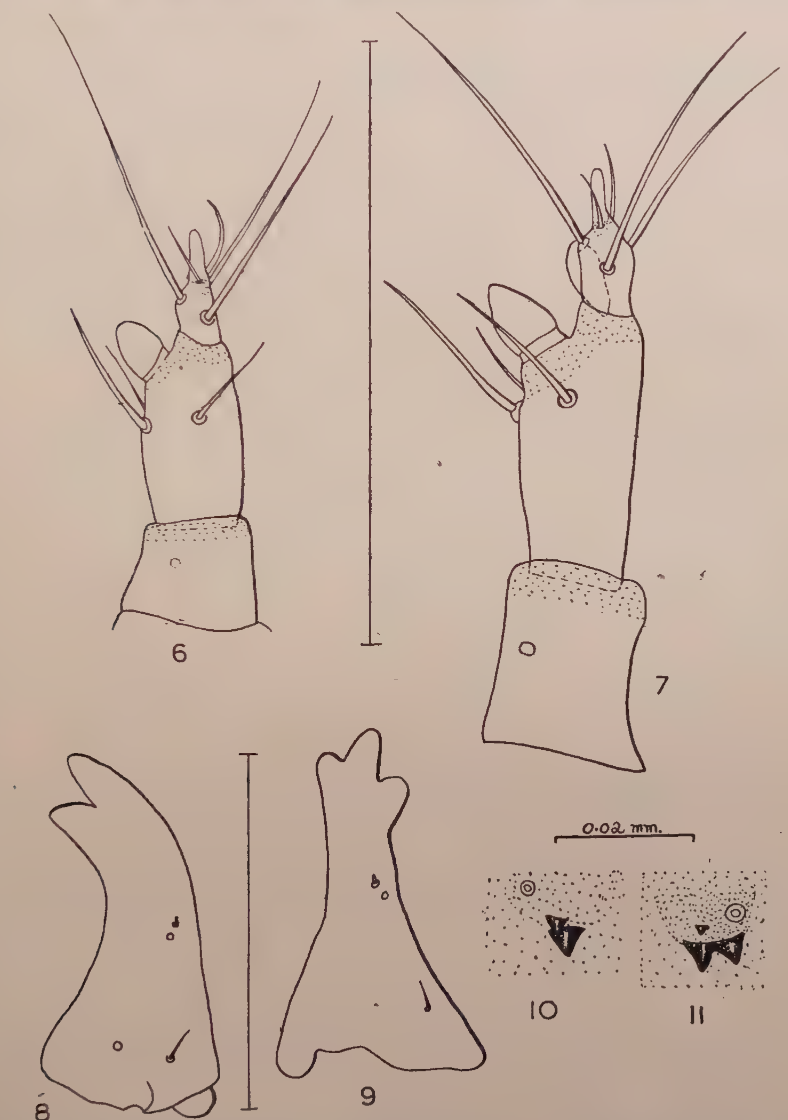
but even before this happens two small black dots appear near the anterior margin of the metatergum, one on each side not far from the median line. Each of these dots or egg-bursters is a small, black, hard, one- or two-pointed



FIGS. 2–5.—Third-instar larva of *Platystethus arenarius* (Fourcroy). (2) Dorsal view of head. (3) Enlarged view of anterior angle of labrum. (4) Ventral view of maxilla and labium. (5) Dorsal view of whole larva to show general appearance. Lines next to these and other text-figures refer to a length of 0·20 mm., unless otherwise indicated.

tubercle as shown in figs. 10–11. A day or more before eclosion these may be seen moving up and down against the inner side of the chorion. Eventually the egg swells, because of the steadily expanding larva inside, and the chorion

becomes very tightly stretched. When this process of swelling has reached a certain stage, the egg-bursters or hatching tubercles penetrate the chorion and



FIGS. 6–11.—Larva of *Platystethus arenarius* (Fourcroy). (6) Dorsal view of right antenna of first-instar larva. (7) Same of third-instar larva. (8) Dorsal view of right mandible of third-instar larva. (9) Outer lateral view of left mandible of same larva. (10) Left-hand egg-burster of first-instar larva. (11) Right-hand egg-burster of same. There is considerable variation in the shape of the egg-bursters, and the right and left sides are often similar.

the latter instantaneously rips transversely across the back of the larva. The young larva then proceeds to climb out of the egg. Of 11 eggs observed while hatching, ten had the chorion broken across the back and one, which was slightly

dry, had it broken across the ventral surface of the larva. Of the ten larvae which actually ruptured the egg by means of the egg-bursters, five withdrew the abdomen from the egg-shell before the head and five the head before the tail.

The duration of the hatching process—from the time the chorion is ruptured to the time the larva has left the shell—varies enormously according to humidity conditions. One larva took more than one hour, whereas another took only one minute and 20 seconds. The remaining nine larvae took two to four minutes each to hatch.

Egg-bursting structures have not previously been noted in the family STAPHYLINIDAE. In this connection it is interesting to note that the egg-bursters are in the same position on the larva as those of many Scarabaeoidea. The egg-bursters remain on the cuticle, and are only lost at the first ecdysis. They thus afford an infallible means of distinguishing between first- and second-stage larvae.

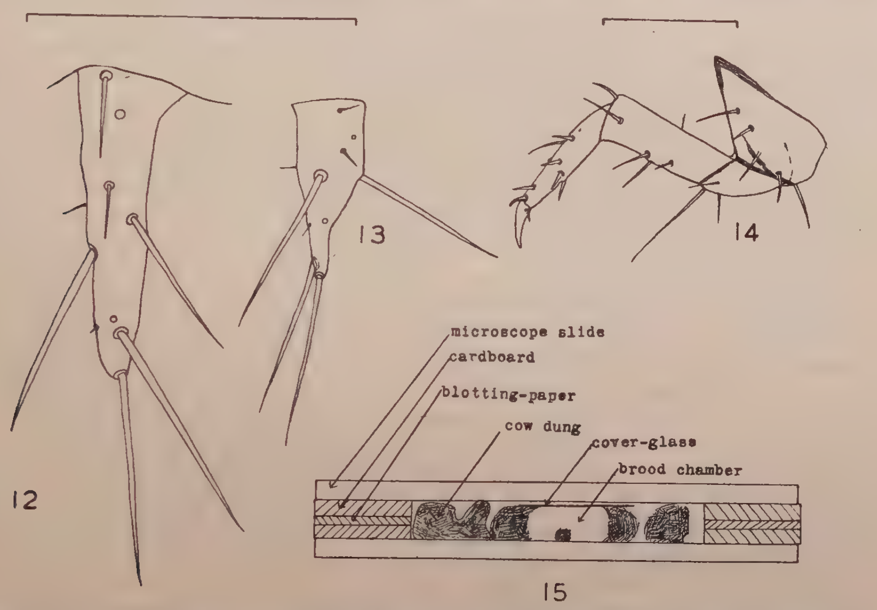
2. *Care of the eggs in the brood chamber.*

Preliminary observations on the female in her egg or brood chamber made it abundantly clear that she would remain in the chamber under conditions which would cause a non-pregnant female (or at least one without a swollen abdomen) to leave immediately. When put under a strong light the female remains in her egg chamber. She not only remains when the walls are torn by a pin or by moving the glass cover, but immediately sets to work in great haste to repair the damage done. On one occasion, the batch of eggs of a female was taken out of her cell and put in a newly made observation cage (type 2—described above), and a few small lumps of cow dung were placed around the egg batch. The female was then transferred to the new cage, and she immediately set to work with " frantic " haste to make a cell around the eggs. Within five minutes the new cell had taken definite shape and was completed shortly afterwards.

On several occasions dead and partly eaten third-instar larvae of *P. arenarius* were found in the egg chambers in the large observation cage (type 1), and on one occasion a pregnant female with a swollen abdomen was found eating a third-stage larva which had just been killed as evidenced by its " twitching " movements. This female had not yet laid any eggs. From these observations it seemed likely that the female did not " passively " guard her eggs and prevent, by her mere presence, predacious insects from entering the chamber, but that she would aggressively defend her eggs against intruders. In order to test this out, the following experiment was made with a female in a cage of type 2. At 10.45 p.m. five nearly full-grown third-instar larvae of *Oxytelus sculpturatus* Grav. were placed in the space outside the chamber. Each of these was slightly larger than the female *Platystethus*. These larvae, which also feed on dung, immediately began to burrow into the dung near the chamber as well as into the walls of the latter. At 10.51 p.m. one of the larvae succeeded in entering the chamber, and the female attacked it without hesitation. The larva and beetle rolled over and over the floor of the chamber, first one on top and then the other, calling to mind a savage dog fight. During this first period, which lasted only a few seconds, it was impossible to see precisely what was happening, as the movements of the combatants were very rapid and further confused by the fact that their bodies were rolling over. In a few seconds, however, they disengaged, and the larva tried to get out of the cell. It could not or did not try to find the hole it had made coming in and had no time to

more than begin to burrow out before it was attacked again by the female. After watching the fight for about half a minute, it became clear that the larva only tried to bite the female when she bit it or jabbed it with her abdomen. Its efforts, which were interrupted every few seconds by the female, were directed, between attacks, to escaping from the chamber.

In about two minutes from the time the larva entered the chamber, it was almost completely incapacitated, and the female had stuffed it into a slight concave irregularity in the wall of the chamber. The larva still continued to twist its body slightly and move its legs feebly. Every few seconds, after rapidly inspecting other parts of the chamber, the female returned to the larva and bit it once or twice and jabbed it many times with the tip of her abdomen.



Figs. 12–15.—(12) Dorsal view of right urogomphus of third-instar larva of *Platystethus arenarius* (Fourcroy). (13) Same of first-instar larva. (14) Anterior face of right hind leg of third-instar larva of same species. (15) Cross-section of No. 2 observation cage.

By 11 p.m. the *Oxytelus* larva was twitching only occasionally. When seen again at 11.15 p.m. it was dead, and it had been dragged out of its corner and left to lie with its thorax touching the egg batch. During the first few seconds of the fight the egg batch was pushed by the combatants from the side of the chamber to the middle of the floor, where it remained until the eggs began to hatch three days later.

The *Oxytelus* larva was at a serious tactical disadvantage from the beginning, apart from the fact that its soft body was much more vulnerable to bites than the hard body of the female. Instead of devoting the whole of its energies to maiming or at least cowing the female, its efforts were so divided between repelling attacks and trying to get out of the chamber that it succeeded in doing neither. The method of attack by the female was most effective and deserves a few words, particularly as it is probable that the same or a closely similar method of attack is used by the majority of the Staphylinidae.

As already stated, it was not possible to see exactly how the female attacked during the first few seconds. After this period, however, the attacks of the female consisted of short runs at the larva when she tried, and often succeeded, to bite it laterally or ventrally, more rarely dorsally. At the same time she curled her abdomen over her thorax and head and gave the larva many very rapid jabs with the tip. The tip of the abdomen sometimes struck a point on the larva just over her head and sometimes the abdomen was slightly twisted laterally so that its tip hit the larva a short distance lateral to the head of the female. The result of this form of attack was that the defensive bites of the larva were divided between the head and tip of the abdomen of the female. The tip of the abdomen is moderately pointed and, besides, is hard and smooth, so that the *Oxytelus* never managed to grip it between its mandibles. Most adult STAPHYLINIDAE have a pair of abdominal glands which open on either side above the anus. These glands secrete an aromatic substance which is used for defence (and offence ?). It seems very likely that these glands exude during an attack, and if this is so they would greatly enhance the amount of attention directed by an opponent to the jabbing abdominal tip.

After the experiment just described was made, it was thought that the female would possibly attack an *Oxytelus* larva under conditions when it could not be protecting its egg chamber or eggs; and in order to test this, two other females were enclosed in glass cells 16 mm. broad and 9 mm. high, and an *Oxytelus* larva of the same size as that used above was put in each cell. One of these females was a five-day-old virgin and the other had not a swollen abdomen but may have been pregnant or may have finished laying. After 24 hours the larvae were undamaged and were then removed. During this period the larva and female in each cell often ran into each other. Each time this happened both backed away hastily, and no attempt to attack on the part of either was seen while the glass cell was actually under observation. As a further check on the aggressiveness of the female in the brood chamber, the point of a bent pin was inserted. The female immediately attacked the point and continued to do so until it was withdrawn. The end of the pin was attacked by biting and jabbing with the tip of the abdomen in the same manner in which the *Oxytelus* larva had been attacked.

The female *P. arenarius* also protects her eggs in another important way. She prevents fungi from growing in the egg chamber. In one cage (type 2) a thick culture of an undetermined species of mould grew in the cow dung around the egg chamber. The hyphae of this mould penetrated to all parts of the cage, but no more than an occasional strand was able to remain for even a short time within the cavity of the brood chamber without being chewed by the female. No experiments were done to test the effect of a relatively unrestrained growth of fungi on *Platystethus* eggs, but from experience in rearing other beetles, it is clear that if eggs become too closely enmeshed in hyphae they will not hatch properly for mechanical reasons, or, if they do hatch, the larvae often remain entangled until they die. Fungal hyphae are able to kill even a pupa by mechanically preventing the adult from emerging. In addition, it appears likely that a number of fungi will directly attack the eggs.

3. *Care of the young larvae in the brood chamber.*

It has already been shown that up to four days may elapse between the hatching of the first and last eggs of a single batch. This means that the female is brought into direct contact with its larvae, since she remains in the egg chamber until or after the last egg has hatched. This tactile knowledge of its larvae

must be of some importance in the behaviouristic pattern of the female owing to the fact that the larvae do not leave the egg chamber immediately upon hatching but remain within for a relatively long period afterwards.

Seven females have been observed through the period of the hatching of the eggs. Variations in behaviour were noted, but it appears likely that some of these variations were due to differences in handling rather than to genetic intraspecific differences. That intraspecific behaviouristic differences are manifested in identical external environments cannot be doubted by even the most casual observer; and they are no more remarkable than major intraspecific differences in the structure of the alimentary canal and central nervous system that have been shown to exist in some beetles (Hinton, 1940).

The following, which typifies the behaviour of the female during the hatching period, is a condensed extract of my notes on a female with 55–60 eggs—the same on which the experiment with the *Oxytelus* larva was made.

Oct. 19th.—Three larvae hatched out before 9.30 a.m. By 10.55 a.m. about 12 larvae had hatched. Larva begins to feed within a few minutes of hatching. Put point of pin in chamber, and it was immediately attacked by female. Female still repairs cell with as much energy as before. Put five 3rd and two early 2nd instar *Platystethus* larvae in cage. 11.15 a.m.—One 2nd instar larva entered chamber. 11.20 a.m.—2nd instar larva not attacked. It leaves chamber. All newly hatched larvae congregated in one corner of chamber where they are falling over one another. 11.30 a.m.—No young larvae had left chamber. 12.55 p.m.—No change. 2.25 p.m.—About half the eggs have hatched. 4.53 p.m.—No young larva has left chamber. About 20 eggs left. Larvae crawling all over chamber and rather evenly distributed within it, not congregated in one part as before. 5.54 p.m.—Many eating dead *Oxytelus* larva. 8.54 p.m.—All young larvae in chamber. Female and many young " avidly " eating a 3rd instar *Platystethus* which must have just been killed, as it is still twitching. About 14 eggs left. 9 p.m.—A small 3rd instar larva entered chamber, and within four minutes female nearly killed it. Female attacked it with much less energy than it had attacked *Oxytelus* larva, and when it was nearly dead stuffed it in a corner. 9.04 p.m.—Two young larvae are biting and eating nearly dead 3rd instar *Platystethus* larva. It thus appears that young larvae may help the female to finish off enemies and therefore help to protect the eggs. 10.43 p.m.—Female and all young larvae still in chamber. 11.40 p.m.—A small cell with a connection to the chamber has been made, possibly by the entry of one of the 3rd instar larvae put in the cage. No young larvae in this secondary cell, but several stuck their heads into it and then withdrew to main chamber.

Oct. 20th, 12.56 a.m.—Female slightly enlarged secondary chamber and repaired its walls. 1.10 a.m.—No change. 1.35 a.m.—No essential change. 5.07 a.m.—Fewer eggs but otherwise no change. 8.23 a.m.—Only four eggs left. 9.09 a.m.—One young larva in secondary cell. 10.20 a.m.—Both 3rd instar larvae dismembered and nearly completely eaten. *Oxytelus* only about one-fourth eaten. Female busily closing an opening to secondary cell. This may have been made by one of the large larvae still left in cage. 12.10 p.m.—Two young larvae in secondary cell. 12.56 p.m.—Only three eggs left. 2.14 p.m.—Three eggs still left. 3.52 p.m.—An occasional young larva enters secondary cell but always leaves right away. This seems to indicate that they are not yet ready to leave brood chamber. 5.50 p.m.—Female added about another fourth to volume of chamber and killed another 3rd instar larva. This new wing to chamber probably started by 3rd instar larva entering. Numerous

young larvae in new wing feeding on dead 3rd instar larva. 6.10 p.m.—Some young larvae occasionally help to line roof (cover-glass) of chamber with dung.

Oct. 21st, 12.20 a.m.—No change. 12.34 a.m.—I broke large piece of wall of chamber and female immediately set to work to repair it. 9.20 a.m.—Cage has been allowed to get too dry. Volume of chamber nearly doubled. Young larvae had not yet moulted as far as I could see, but a number had definitely left chamber. Female abdomen swelling rapidly again, and no doubt will lay again, as some females I have had laid up to three batches. None of the latter had been fertilised between batches. All eggs hatched.

The essential features of the hatching period described above have been confirmed with other females. The most notable variation observed concerned the time of leaving the brood chamber. One of the six other females on which experiments were made left the brood chamber before the last two eggs had hatched, and the five remaining stayed until shortly after the last egg hatched. Three brood chambers containing large numbers of eggs but no female were found in the field, as well as a number in which all eggs had hatched and the female remained with the young. Many eggs have been hatched and young larvae reared in the laboratory without the assistance of the female beetle.

The behaviour of the females in the brood chambers appears to justify the following conclusions :—

(1) Until the female leaves the brood chamber she attacks intruders about as energetically as she does during the early stages of the incubation of the eggs.

(2) During the incubation and hatching period of its eggs, a female will not attack introduced first-stage larvae of another female of its own species. This was confirmed in experiments with three females.

(3) Young second-stage larvae of *P. arenarius* do not appear to be attacked. Large second- and all third-stage larvae are attacked by the female if they enter the brood chamber. Further experiments are required to discover the factors which confer immunity upon some second-stage larvae. As far as larvae of *P. arenarius* are concerned, immunity from the female in the brood chamber appears to depend on size alone.

(4) The larvae appear to have a strong gregarious instinct from the time they hatch nearly to the time of the first moult. This may not be a true gregarious instinct but simply an instinct to remain in the brood chamber nearly to the time of the first moult.

(5) Larvae normally leave the brood chamber before the first moult.

(6) Young larvae do not attack the eggs, each other, or intruders, but will feed on older larvae partly killed by the female if the body fluids of these older larvae are exuding.

(7) Young larvae will feed on the bodies of older larvae and those of *Oxytelus sculpturatus* Grav. when these have been dead for several days. They are facultative carrion feeders.

4. *Habits of the larvae.*

When the larva leaves the brood chamber, it makes a feeding chamber for itself. These chambers may be broadly oval in shape or narrow and long. The larva feeds on cow dung more or less continuously night and day until it is full grown. It is not predacious, but it may feed on dead insects it happens to find in cow dung. The larvae do not attack each other. This is true even when they are confined for long periods in crowded conditions without food. Fifteen young third-instar larvae and one pupa were placed without food on a

moist blotting-paper in a tube 2 × 0·4 inches. At the end of two days, three newly emerged larvae were added. At the end of three days no larvae were eaten nor injured, and the defenceless pupa was intact. Throughout this experiment the larvae were kept at 25° C. ± 0·50 and a relative humidity of 95–100%. No experiments were made under less humid conditions, and it is possible that a lack of moisture may induce cannibalism. A low relative humidity or a low moisture content of the food is known to enhance the percentage of cannibalism in other insects, e.g. *Tenebrio molitor*.

Apart from feeding, the larva spends much of its time enlarging its chamber and repairing it. This chamber is repaired in the same way as the female repairs her brood chamber. The small and often much-chewed pieces of dung used to repair it are frequently held at right angles to the long axis of the head, the curious lateral projections of the labrum (figs. 2–3) facilitating this. In the female, the ventral lining (epipharynx) of the labrum, which projects forwards beyond the dorsal part and has a broad and deep emargination densely lined with spines, helps to hold small pieces of dung in the same way. The larva, like the female, also often uses the top of its head to press pieces of dung against the roof of its chamber.

After the larva is fully grown, it stops feeding and wanders about in search of a suitable site in which to construct its pupal chamber. The exact length of this wandering period was not determined, nor can I positively say that all larvae go through such a period, but I believe that they do. In this wandering period the larva appears to be much more brightly yellow, as the full colour effect of the accumulated fatty reserves showing through its transparent cuticle is not obscured by food in the gut, as is the case before it stops feeding. When a suitable place is found, the larva constructs a chamber. In a few instances, larvae in petri dishes pupated on the glass or on the blotting-paper, but this was probably due in each case to the fact that the larva had been disturbed several times while commencing a pupal chamber and had therefore finally come to the end of the period when it could—for physiological reasons—postpone the commencement of its pre-pupal stage. One or two days before the larva actually pupates, it goes through a more or less motionless pre-pupal period or stage when it is not capable of walking or, in point of fact, moving its legs more than very slightly.

5. *Pupation.*

The pupal chamber is usually about 4 mm. long and 2 mm. wide, but one chamber made partly in dung and partly in the blotting-paper was 4 mm. long and 3 mm. wide. The pupal chamber varies in shape as already indicated, but when made entirely in dung it is round in cross section with each end moderately narrowed. It is made in the cow dung, or in the earth immediately beneath the dung, or partly in the dung and partly in the earth. The inner walls of the pupal chamber are no smoother than those of the feeding cells, and, when constructed where there are large undigested pieces of plant material, are often irregular.

The pupa normally wriggles itself free of the last larval skin. If humidity conditions are not suitable, for example if the dung has been wetted too much, the pupa may find it difficult or even impossible completely to shed the last larval skin. It is not enclosed in a cocoon, and apparently no silk is produced by the larva, as is the case with some ALEOCHARINAE and STENINAE. The pupa normally lies on its back in the pupal chamber. However, when the pupa is placed in the open on moist blotting-paper, its resting position varies con-

siderably. Of six tested under identical conditions, three lay on their backs, two on their sides, and one on its ventral surface.

6. *Total duration of life-cycle.*

The total duration of the life-cycle—from the time the egg is laid to the time the adult emerges from the pupa—is 29–35 days at 25° C. ± 0·50 and a relative humidity of about 85–95%. The relative humidity in the incubator was 70–75%. The time taken for the life-cycle is divided as follows: egg, 4–5 days; first-instar larva, 3–4 days; second-instar, 4–5 days; third-instar, 12–14 days, including the wandering period; pre-pupal stage, 1–2 days; pupal stage, 5 days. The duration of the life-cycle will, of course, vary greatly according to such factors as temperature, amount and quality of dung available, and relative humidity.

Summary.

1. The occurrence of sub-social habits in beetles is briefly reviewed. For further information von Lengerken (1939) should be consulted.

2. The life-cycle of *Platystethus arenarius* (Four.) has been worked out.

3. The female of *P. arenarius* constructs a brood chamber in cow dung. She remains in the brood chamber throughout the incubation of the eggs and usually during the first few days of the life of the young larvae. During this period she will attack other insects entering the brood chamber. She also protects her young against fungi.

4. Both larvae and adults of *P. arenarius* will feed exclusively on cow dung. Larvae fed exclusively on cow dung will produce normal adults.

5. Egg-bursters have been described for the first time in the Staphylinidae.

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DESCRIPTION OF 4TH-INSTAR LARVAE OF *AEDES* (*MUCIDUS*) *GRAHAMI* THEOBALD (DIPTERA)

By Sergeant G. W. SHIELD, B.Sc., R.A.M.C.

WITH ONE TEXT-FIGURE.

SPECIMENS of *Aedes* larvae of the subgenus *Mucidus* were found breeding in a temporary rain pool at the side of Amanful–Kwesimintim footpath near Takoradi, Gold Coast Colony.

No description of the known *Mucidus* larvae listed by Hopkins in 1936, *Mosquitoes of the Ethiopian Region* **1**, would completely fit the specimens, and it was thought that these might prove to be the undescribed larva of *Aedes* (*Mucidus*) *grahami*. Lieut. J. D. Robertson, R.A.M.C., has previously noted the presence of this species in the area (*in litt.*).

Specimens were therefore isolated and bred out individually and the larval skins were kept and mounted.

Only limited numbers of larvae were found and it has only been possible to obtain three skins which correspond with adults individually. No difference could be seen between these larval skins and other larvae of the batch which failed to pupate and were preserved as larvae. The three adults which emerged clearly belong to the species *Aedes* (*Mucidus*) *grahami* and a description of the larva has therefore been made.

Size: approximately 9 mm. from head to gill tip. *Colour*: brown with darker siphon and mouth brushes. *Habitat*: present in clear pools of rain water in a grassy ditch hiding amongst dead and once-dried palm leaves. Actively predacious on other mosquito larvae in the same pool but not observed to attack one another. No earlier stages were seen, however, and it was therefore impossible to note whether the 4th-instar larva would attack earlier instars of the same species. *Head*: The head is squarish as in other members of the subgenus with a similar chaetotaxy. The mouth brushes are adapted for predacity and each individual component is ctenate as in *Culex* (*Lutzia*) *tigripes*. The antenna is sparsely spiculate with minute terminal setae and reduced antennal seta. *Abdomen*: The comb is a patch of approximately 50–60 scales, each with a broad apical fringe. The shape of individual scales varies considerably. The siphon tapers slightly and has a siphonal index of approximately 5 in life. The subventral tuft is 4–6 branched and inserted rather more than half-way along the siphon. A pecten of approximately 20 spines extends for $\frac{1}{3}$ or rather more of the length of siphon. Each spine has a single secondary denticle, which denticle is sometimes reduced almost to a shoulder on the more distal spines and may be completely absent from the last. The ventral brush is very well developed and there is a conspicuous barred area. The gills are short, approximately half the length of the saddle and are brown in colour (comparatively heavily chitinised ?). The saddle is spiculate on the postero-dorsal margin.

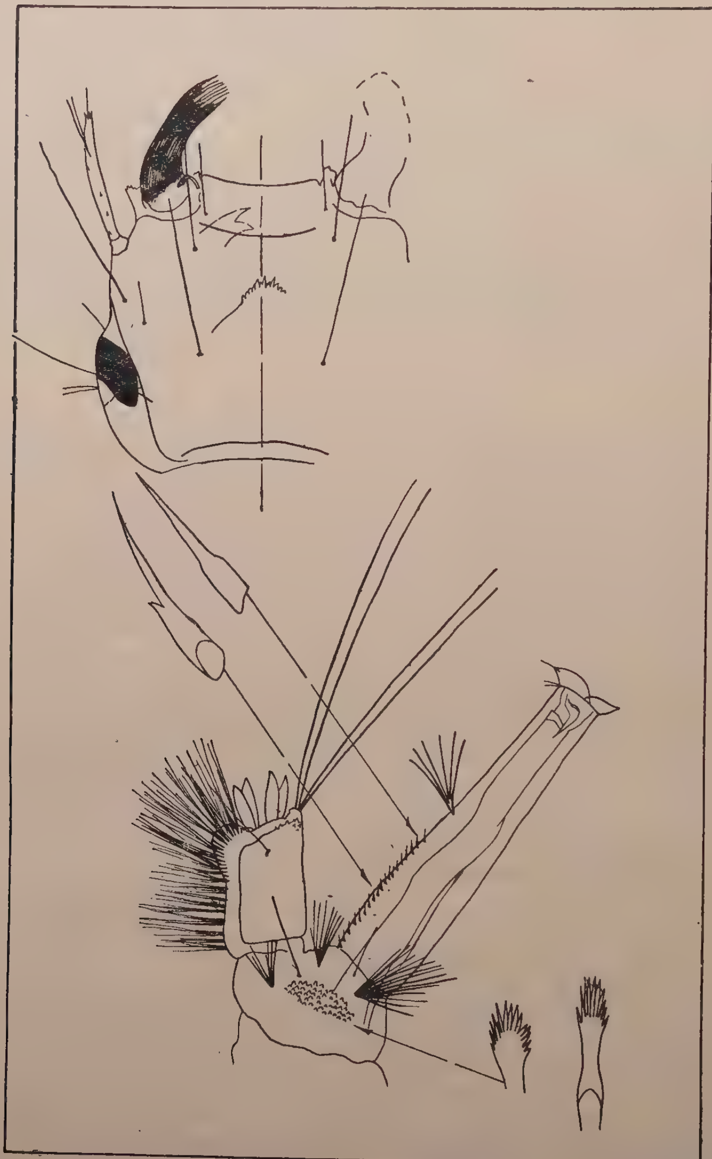

FIG. 1.—Details of the 4th-instar larva of *Aedes* (*Mucidus*) *grahami* Theobald.

The accompanying diagrams are as accurate as possible, but in the absence of a camera lucida they are perforce freehand drawings.

No larvae of the other species of subgenus *Mucidus* were available for examination. The material is being forwarded to the British Museum (Natural History).

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SENSILLAE OF THE ADULTS AND LARVAE OF THE BEETLE *RHIZOPERTHA DOMINICA* FAB. (BOSTRICHIDAE)

By A. C. Crombie.

With Seven Text-figures.

It has been shown experimentally (Crombie, 1941) that the olfactory organs of adult *Rhizopertha* of both sexes must be located on the legs and antennae (cf. Minnich, 1929; Eltringham, 1933; Marshall, 1935; Imms, 1937; Wigglesworth, 1939; Frings, 1941). These appendages were examined for possible chemoreceptive sensillae. Freshly emerged adults with soft cuticle were chosen. Antennae and legs were embedded by the dioxan method and by the methyl benzoate and celloidin method. Sections of 3 μ to 10 μ thickness were cut and stained with either Mann's methyl blue eosin, iron haematoxylin, or Mallory's phosphatungstic acid iron haematoxylin. The last gave the best results and brought out the nerve fibres very clearly. The same technique was also employed in preparing stained sections of freshly moulted larvae.

The club-segments of the antennae bear two types of sensillae (fig. 1): long pointed trichoid setae with thick walls, each in a distinct socket; and short blunt setae with very thin walls and bases sunk below the general surface of the cuticle but without a distinct socket. The two types are equally numerous. The trichoid setae project out beyond the thin-walled setae and presumably protect them. Both types have a trichogen cell and a bipolar sense cell at the base. The thin-walled setae evidently contained fluid during life, for in the sections the contents were faintly stained and vacuolated. They are possibly olfactory in function, while the trichoid setae may be tactile.

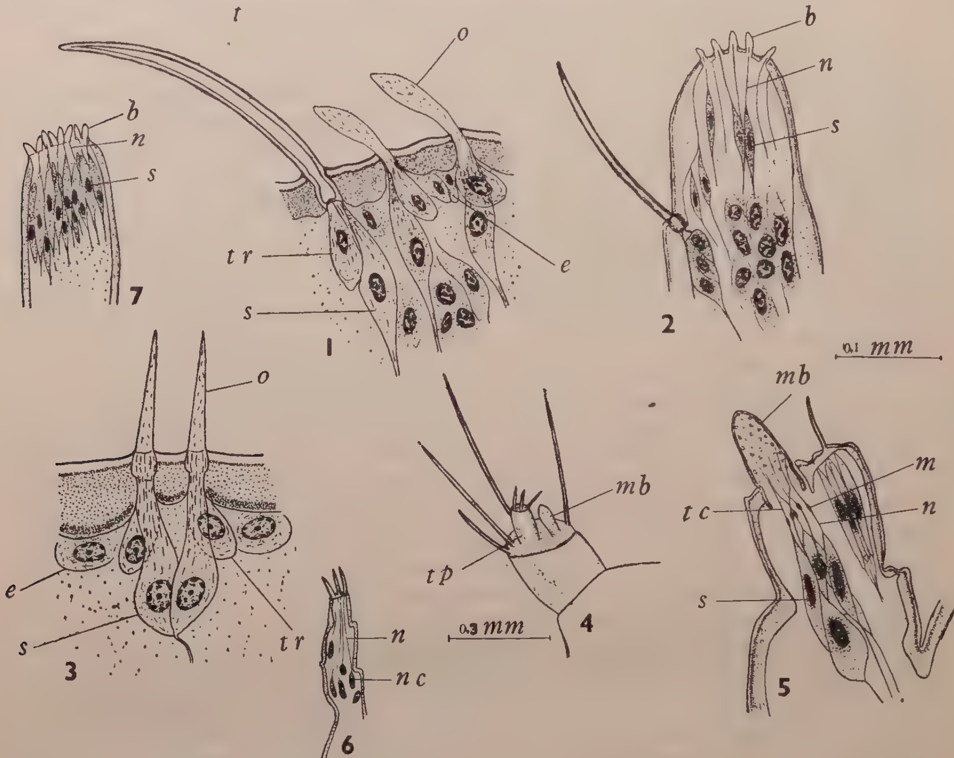
Besides numerous thick-walled trichoid setae on the different parts of the leg, a relatively small number of small pointed setae with very thin walls and no distinct socket were found on the tibia (fig. 3). Each of these had a trichogen cell and a bipolar sense cell at the base. The contents of these setae were faintly stained. The evidence suggests that they may be olfactory sensillae (Crombie, 1941).

The labial and maxillary palps have at their tips a group of thin-walled basiconic setae, each with a nerve running to a bipolar cell (fig. 2). These sensillae are possibly tactile. Experimental work has failed to show that they are chemoreceptive (Crombie, 1941).

Short blunt setae similar to those found on the antennae of *Rhizopertha*, with thin walls and supposed chemoreceptive function, have been found on the antennae of other insects; *e.g.* the adults of *Mormoniella vitripennis* (Jacobi, 1939), *Tenebrio molitor* (Valentine, 1931), and *Rhodnius prolixus* (Wigglesworth and Gillet, 1934). Similar organs have also been found on the tarsi of adult Lepidoptera (Eltringham, 1932).

The sense-organs found on all larval instars from first to fourth are similar. The antennae (fig. 4) bear long trichoid setae, a single multiple-celled basiconic sensilla (fig. 5), and a papilla bearing small trichoid setae with thick walls (fig. 6). The multiple-celled basiconic sensilla (fig. 5) is innervated by 5 nerves each running to a bipolar sense cell. The cuticle of this sensilla is not very thin, but its surface seems to be pitted, the cuticle appearing to be much thinner in these pits. Dethier (1937) found similar sensillae on the antennae of lepidopterous larvae. According to Snodgrass (1926, 1935), in such sensillae the minute bodies (m) on the nerve may be cuticular structures, and the terminal connections (tc) going beyond them to the sensilla may be cuticular processes. There is one of these minute bodies to each sense cell (s). The palps of the larvae bear

basiconic setae (fig. 7) similar to those on the adult. The body and legs are covered with numerous thick-walled trichoid setae (cf. Hilton, 1902).



Adult sensillae : Fig. 1 antenna, Fig. 2 maxillary palp, Fig. 3 tibia.
Larval sensillae (third instar) : Fig. 4 antenna, Fig. 5 multiple-celled basiconic sensilla of antenna, Fig. 6 trichoid-bearing papilla of antenna, Fig. 7 labial palp.

t = trichoid sensilla ; b = basiconic sensilla ; o = olfactory sensilla ; m.b. = multiple-celled basiconic sensilla ; e = epidermal cells ; tr = trichogen cell ; s = sense cells ; n = nerve ; nc = nucleus ; tc = terminal connection ; m = minute body on terminal connection ; tp = trichoid-bearing papilla. All drawn to the same scale except fig. 4.

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OBSERVATIONS ON ACULEATE HYMENOPTERA

By O. W. Richards, M.A., D.Sc., F.R.E.S.

On the edges of Langley Park, near Slough, Bucks, are some raised gravelly banks, partly covered with sparse grass, and frequented by many species of bees and wasps. All the following observations unless otherwise indicated were made in this locality.

(1) *Trypoxylon figulus* (L.) nesting in the ground.

In the account of the biology of this species (Hamm and Richards, 1930 : 118), Smith's (1848) record of a colony nesting in a sandbank was perhaps too summarily dismissed. While it would be unusual to find *T. figulus* living in what might properly be described as a colony, it certainly can nest in the ground, using burrows of other insects.

On 15.v.43, a female was seen to enter a burrow, probably made by a bee in the previous year but perhaps a little enlarged, in a small perpendicular gravel face. The burrow was excavated for 6·0 mm. straight inwards (horizontally) and then turned at right angles and ran parallel to the gravel face about 1·0 cm. in from it and sloping gradually downwards, the total length of the burrow being about 5·0 cm. At the inner end of the burrow were two cells, the lower one fully stocked and closed, the outer one not quite stocked and open.

The spiders in the cells (kindly determined by Dr. W. S. Bristowe) were as follows :—

Bottom cell : *Theridion bimaculatum* L. 8 ♂, 5 ♀.
T. redimitum L. 1 ♂, 3 ♀. Possibly 1 to 3 spiders lost.
Outer cell : *T. bimaculatum* 1 ♂, 1 ♀.
T. redimitum 4 ♂, 4 ♀. Also one or two spiders lost.

The spiders were all immature and according to Dr. Bristowe must have been captured in low herbage. When the nest was excavated the spiders were motionless but by next morning they were capable of considerable movement, though scarcely of walking.

(2) Nest of *Crossocerus anxius* (V. de Lind.).

Hamm and Richards (1926 : 315) recorded no British nests of this species but gave four records of prey belonging to the genus *Tachydromia* (Empididae). Of the continental records quoted, one refers to *Tachydromia*, one to *Tachista* of the same family and one, possibly due to an error of observation, to a Capsid bug.

On 5.vi.43, a female was seen entering a small burrow, about 2·0 mm. diameter, in a flat part of a clayey, gravelly bank. The nest was excavated and two cells were found at the depth of about 5·0 cm. One cell was not completely stored, the other stored but containing two Dipterous larvae, possibly of *Metopia leucocephala* (Fall.) (Tachinidae), of which the adults are abundant on the bank. In all, 16 prey were recovered, 15 ♂ *Tachydromia verralli* Collin (det. J. E. Collin) and one specimen which may be a damaged female of the same species.

(3) Nest of *Entomognathus brevis* (V. de Lind.).

This species (Hamm and Richards, 1926 : 320) is well known to nest in the ground and to prey on Chrysomelid, especially Halticine, beetles. On 26.vi.43, a female was seen to enter a hole on the top of a bank where the surface was nearly flat. The burrow was 2·0 mm. in diameter and went vertically downwards about 6·0 cm. through a layer of loam and just into hard yellowish clay. The cells were broken in digging them up but there was probably one fully stored and one half stored. The following Halticine prey were recovered: *Chalcoides aurata* Marsh. 3, remains of four more *Chalcoides* spp., *Chaetocnema concinna* Marsh. 1, *C. hortensis* Geoff. 3.

(4) Observations on *Ectemnias dives* (Lep. et Br.).

Yarrow and Guichard (1941 : 11) have summarised the British records of this species. A good deal of evidence suggests that it has been introduced to this country with timber, but if this is so, some of the records are puzzling. It is at least clear that the species is now rapidly expanding its range. The first specimen obtained at Slough was 1 ♂, Imperial College Field Station, 24.viii.36, on flowers of *Danaus*. In 1943 and 1944, it was found not uncommonly in Langley Park, mostly flying round old oak-stumps. The canal with a large woodyard is only about 100 yards away.

Almost nothing is recorded of the biology of this species on the continent. Sickmann (1893 : 58) records that it nests in old tree-trunks and preys on flies.

On 18.viii.27, I found a large colony of this species nesting in a fallen cherry-log, in the rocky scrub on one side of the gorge of the R. Tarn, France : Lozère, Ste. Enimie. A number of cells were excavated and the following prey, kindly determined by Mr. J. E. Collin, were obtained :—

Cell I. Syrphidae : *Pipizella* ? *annulata* Mcq. 1 ♀, *Sphaerophoria scripta* L. 3 ♀, 4 ♂.

Cell II. Syrphidae : *S. scripta* L. 1 ♂, 3 ♀, *Syritta pipiens* L. 1 ♀, *Paragus* ? *tibialis* Fall. 1 ♀.

Cell III. Syrphidae : *S. scripta* L. 3 ♂, *P. tibialis* Fall. 1 ♀, *Chilosia scutellata* Fall. 1 ♀, *Melanostoma scalare* Fab. 1 ♀. Tachinidae : *Gymnosoma rotundatum* L. 1 ♀.

Cell IV. *S. scripta* L. 4 ♂, *S. pipiens* L. 1 ♂, *P. tibialis* Fall. 1 ♀, *P.* ? *annulata* Mcq. 1 ♀. Later 3 ♂ *Cystomutilla ruficeps* (Sm.) were bred as parasites from this cell.

The following prey were dug out of the wood, but could not be assigned to particular cells: Syrphidae : *S. scripta* L. 4 ♂, 1 ♀; *Paragus bicolor* Fab. 1 ♂, 5 ♀; *P. tibialis* Fall. 2 ♀; *P. 4-fasciatus* Mcq. 1 ♀; *S. pipiens* L. 1 ♀; *Pipizella* sp. 1 ♀; Tachinidae : *Gymnosoma rotundatum* L. 1 ♂; *Exorista* ? *aemula* Mg. 1 ♀.

(5) Miscellaneous records of prey.

Pompilidae : *Calicurgus hyalinatus* (Fab.). A female seen running backwards with an *Aranea cucurbitina* L. ♀ (det. W. S. Bristowe) on top of a bank and climbing to the top of a grass-stem, as if for flight, 5.vi.43. *Pompilus trivialis* Dahlb. A large female seen dragging *Trochosa terricola* Thor. ♀ (det. W. S. Bristowe) into a burrow in loose earth amongst sparse grass on a bank, 19.ix.43. The burrow was 2·5 cm. long.

Psenidae : *Mimesa shuckardi* Wesm. Two females each carrying an *Oncopsis flavicollis* L. ♀ (det. W. E. China), 20.vi.43.

Cerceridae: *Cerceris rybyensis* (L.) carrying *Halictus calceatus* (Scop.), 26.vi.43.

(6) Two generations of *Nomada fucata* Panz. and the host of *N. flavopicta* (Kby.).

Andrena flavipes Panz. is common in the Slough district, but only the colony at Langley Park seems to be attacked by *N. fucata*, which is extremely local in this country, although abundant in Germany, where it is regularly double-brooded, like its host. Perkins (1919 : 240) suggests that *N. fucata* attacks only the second brood of *A. flavipes* and apparently hitherto no spring specimens of the *Nomada* have been recorded in this country. At Langley Park, however, in both 1943 and 1944, the *Nomada* was abundant and occurred in two broods. In 1943, for instance, females were seen on 18.iv., 15.v., 20.vi., 26.vi., 11.vii., 25.vii., 2.viii. The females on 26.vi. were the last of the first brood; for some reason no males were seen in 1943. In 1944, the following were recorded: 10 ♂, 32 ♀ 12.iv.; 2 ♀ 29.v.; none 17.vi.; 1 ♂, 8 ♀ 15.vii.; 5 ♂, 8 ♀ 23.vii.

Smith (1891 : 128) records that he observed *Nomada flavopicta* (Kby.) (*jacobaeae* Auct.) enter the burrow of *Andrena flavipes* [*fulvicrus*] in August. This observation does not seem to have been repeated and the only certain host of the *Nomada* is *Melitta leporina* (Panz.) (Stöckhert, 1933 : 158; Yarrow, 1941). Other species of *Andrena* have also at times been suggested as hosts (Stöckhert, *loc. cit.*). From my own observations in Cornwall and Dorset, *M. leporina* Panz. is the most likely host in the places where I collected. At Langley Park, however, a number of *N. flavopicta* have been taken flying over the colony of *A. flavipes*; several other *Andrena* species are present but none nearly so common. No species of *Melitta* has been observed near Slough during the last 15 years. A comparison of the Langley Park specimens with the specimens from elsewhere shows certain differences; these may, of course, be due to geographical reasons rather than to difference in host.

♀. Bucks. Clypeus with ventral half yellowish-orange; legs more yellow, less orange, yellow marks on hind coxa conspicuous. 2 out of 5 specimens with small yellow marks on sides of propodeum.

♀. Cornwall, S. Devon, Dorset, Is. of Wight. Clypeus almost entirely black, usually only a thick line of orange at ventral margin; only 1 ♀, S. Devon: Bovey Tracey, 13.viii.00 (*A. H. Hamm*) approaches the Bucks type. Legs less yellow, more reddish, pale marks on hind coxa less conspicuous and usually reddish rather than yellow. 1 out of 10 with yellow marks on propodeum.

♂. Bucks. 2 out of 3 with a fairly large yellow spot on base of sternite II. Probably a greater tendency to yellow markings, but owing to the larger amount of yellow in this sex, the effect is less marked than in female.

♂. S. Devon, Dorset, I. of Wight. 1 out of 8 with a minute yellow spot at base of sternite II.

(7) Observations on *Sphecodes* Latr. (Apidae).

S. reticulatus Thoms., normally a rare species, is sometimes common at the Imperial College Biological Field Station, Slough, and usually so at Langley Park. There is some controversy about the host of this parasite. Saunders (1896 : 198) suggests that *Halictus prasinus* Sm. is the host. Perkins (1919 : 254) gives *Andrena argentata* Sm. as the host. Stöckhert (1933 : 101) records *A. argentata* Sm. and *A. barbilabris* (Kby.) (= *sericea* Chr.) as hosts and doubts the record of *Halictus prasinus*.

Neither of the two above species of *Andrena* (nor *H. prasinus*) occurs or is likely to occur near Slough, and because of the commonness of the *Sphecodes*, the host must be a species which is common locally. I think from the way the species occur together, that the host in this district is the second brood of *A. dorsata* (Kby.). The *Sphecodes* occurs in Aug. and Sept.

S. niger von Hag. is a species which is rare throughout Europe and appears to have been reported only once in this country, the record being from E. Sussex, Guestling (E. Saunders, 1896 : 200). At Langley Park, 2 ♂ were captured 10.ix.42 and the males were rather common in 1944, 7 ♂ 27.viii., 5 ♂ 17.ix. So far the female has not been captured but the species is very difficult to distinguish in the field from the numerous small species of *Halictus*. The host of *S. niger* is uncertain, but it seems unlikely to be any rare species. No unusual species of *Halictus* occurs at Langley Park, for instance, and far the most abundant species there is *Halictus morio* (Fab.).

On the continent, Alfken (1913 : 62) has suggested *H. lucidulus* Schk. (*gracilis* Mor.) (non-British) as the host. Minkiewicz (1935 : 194) suggests that *Halictus morio* (Fab.) is the host in C. Poland. Blüthgen (1934 : 63) regards *H. lucidulus* as one host but states that there must be others as the parasite is found outside the range of this species. Stöckhert (1933 : 104) suggests that *H. nitidiusculus* (Kby.) is a host; this species occurs at Langley Park, but is much rarer there than *H. morio*.

Another uncommon *Sphecodes* which occurs rather commonly at Langley Park is *S. rubicundus* von Hag., associating with one of its usual hosts, *Andrena labialis* (Kby.).

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A NOTE ON VARIATION IN LIVING *GLOSSINA BREVIPALPIS* NEWSTEAD (DIPTERA), WITH PARTICULAR REFERENCE TO A RED-COLOURED FORM FOUND IN NATURE

By E. D. Burtt, Ph.D., F.R.E.S.

The normal appearance of *Glossina brevipalpis* is too well known to call for detailed description; it is a large dark brown tsetse fly bearing lighter coloured markings of a more or less dusky, or smoky grey (Newstead 1924).

From April to December 1937 the writer was engaged in trypanosomiasis investigations near Amani, Tanganyika Territory, in the course of which 18,518 male and 966 female *G. brevipalpis* were collected. It was remarked that the colour of the lighter areas of chitin frequently varied in the living fly between one individual and another in relation to the lighter-hued bands on the dorsal side of the abdomen. The colour ranged from the smoky grey normal to the dried specimen, through more or less fulvous or burnt sienna hues. From one locality specimens were markedly infuscated, and thus of a somewhat melanic appearance. In all these variations the slight coloration did not persist long after death.

In addition to the foregoing, a single outstanding variant was noticed. In this, all the parts which are paler hued in the normal fly were vivid blood-red in colour—viz. at the base of the antennae, on the legs and thorax as well as both upper and lower surfaces of the abdomen. At first glance the appearance presented was rather that of a fly gorged with fresh blood, but in all the examples the abdomen was empty. This coloration, as in the case of the slight variants above mentioned, did not persist long after death. A total of 10 males and 1 female were taken. They were found disseminated throughout the area, and were not confined to any particular locality. These were possibly flies in which a gut rupture had occurred after a previous meal, whereby blood had been released into the haemocoel and persisted there. If this is the explanation, the condition would be analogous to that recorded by Wigglesworth (1931) and Kemper (1932) for *Cimex lectularius*.

The cause for this red coloration in *G. brevipalpis* was not investigated. The author places the occurrence on record so as to stimulate further observations on the subject. As far as he is aware, no similar observation has been recorded in relation to tsetse flies in nature, although red-coloured individuals, presumably with ruptured gut, do occasionally occur in the course of laboratory work, particularly when the flies have been maintained under unfavourable conditions.

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NOTE ON THE COURTSHIP OF *EUPLOEA CORE CORE* CR. (LEP. DANAIDAE)

By D. G. Sevastopulo, F.R.E.S.

With a Comment by Prof. G. D. Hale Carpenter, M.B.E., D.M., F.R.E.S.

I have often noticed males of *E. core*, with protruded anal brushes, flying slowly over a piece of waste ground on which I collect, but it is only recently that I have seen the actual courtship display. On this occasion my eye was caught by a specimen of *core* hovering about two feet above the ground. On going closer I saw that it was a male hovering with short, quick strokes of its wings, very unlike the usual slow flap it employs for its sailing flight, and protruding and withdrawing its anal brushes. A female was resting with closed wings on a leaf below. Every few seconds the male flew lower and buffeted the female until finally she flew away, closely followed by the male. I did not see copulation effected.

This particular piece of ground swarms with the four common Calcutta Danaids, *Danaus chrysippus* L., *D. plexippus* L., *D. limniace* Cr. and *Euploea core* Cr., the former two being without anal brushes. I have never, however, seen *limniace* flying with the brushes extruded; *core*, on the other hand, can always be seen sailing slowly along with brushes protruded and the abdomen carried curved downwards and forwards. The presence of a female does not seem essential for this behaviour.

D. G. Sevastopulo, F.R.E.S.

Calcutta, 28.iii.44.

It seems useful to bring together, as a note to this interesting new observation, such previous accounts as have been contributed by other naturalists. The fact that the observation on the courtship of *Danaus chrysippus* L., possibly the commonest butterfly in the world, is still unique, shows what need there is for more notes on this fascinating topic.

G. D. Hale Carpenter.

June 1944.

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A NOTE ON THE CONDITIONS OF PUPATION OF *MUSCA DOMESTICA VICINA* (DIPTERA) IN PALESTINE, AND ITS APPLICATION

By B. Feldman-Muhsam.

Most authors dealing with the pupation of the house-fly, *Musca domestica*, suppose that after reaching the prepupal stage the larva migrates from the manure heap in search of more favourable conditions for pupation, *i.e.* cool and dry surroundings. In a previous paper [1] it was mentioned that no such migration had been observed in Palestine. Under the climatic conditions of Palestine, the surface of the fresh manure dries one day after it has been heaped, and forms a crust which thickens progressively in the succeeding days. Beneath this layer, *i.e.* at a depth of 10 cm., both development and pupation take place. This is the course of events in manure heaps which are neither moistened nor placed within a concrete pit; a similar process is seen in laboratory rearings.

Larvae reared normally on fresh cow dung develop and pupate in the dung under the upper dry crust. If the dung is too dry the development of the larvae is retarded; the larvae remain small, and pupation is delayed if it takes place at all. On the contrary, if the dung be very wet, larvae develop almost normally; but as they reach the prepupal stage they escape from the rearing jars. At this stage a negative tropism to moisture induces a migration of the larvae from the wet surroundings. This migration takes place only in a dark room or at night, as the negative phototropism of the larvae is stronger than their negative tropism to wetness. It has already been noticed by Baber [2] that the larvae migrate from the manure heap only at night. As a matter of fact, the migration takes place, if at all, in the dark and not only at night.

In order to induce a migration from the manure heap or the rearing jars, it

[1] B. Feldman-Muhsam (1944), Studies on the ecology of the Levant housefly. *Bull. ent. Res.* **35**: 53–67.

[2] E. Baber (1925), Fly control by means of the fly-larval-trap manure enclosure. *J. R. Army med. Cps.* **45**: 443–452.

must be ascertained beforehand that the larvae have reached the prepupal stage, *i.e.*, that they have a white-yellowish colour and that the alimentary tract contains no more food. If the dung be then moistened, the larvae will instantly begin to leave it. This migration lasts for 2–3 days; younger larvae continue to develop in the wet dung until they reach the prepupal stage.

Practical applications.

1. Anti-fly campaigns generally cover the larval stage. Different types of larval traps based on the principle of the migration of the larvae from the manure heap have been designed for this purpose. Such traps will be most efficient if the manure be moistened in due time.

2. The following method of rearing house-fly larvae for poultry food based on these observations on the conditions of pupation has been worked out.

The rearings are best carried out in large clay vessels filled up with fresh dung. The vessels should not exceed 30 cm. in depth as the larvae do not penetrate deeper. After having been kept for one or two days in a place rich in flies in order to obtain large oviposition, the vessels should be transferred to a dark hut or barrack. About six days after the beginning of the rearing it is necessary to verify if the larvae have reached the prepupal stage. When they have reached this stage the dung should be thoroughly wetted, and put in a dish conveniently larger than the rearing vessel. All the larvae migrating from the dung will fall into the dish, and thus a huge number of larvae may be obtained.

This method may also be useful in zoological gardens for feeding insectivores, and in laboratory experiments when pupae are needed.

The chemical analysis of the larvae showed that they contain: water, 71·4%; proteins, 18·6%; fats, 5%. The other 5% is probably carbohydrates and salts which have not been analysed. As to vitamins, it has been found that the larvae are very rich in riboflavin (3 mg. per 100 gm. larvae), but comparatively poor in carotins (0·4 mg. per 100 gm. larvae). No vitamin A was found.

In concluding this note I wish to thank Dr. J. Lichtenstein for the chemical analysis, and Miss L. Bichovski and Dr. K. Gugenheim for the analysis of vitamins.

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MEETINGS
TO BE HELD IN THE SOCIETY'S ROOMS
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1945.

WEDNESDAY,	January	17	(ANNUAL MEETING)
,,	February	7	
,,	March	7	

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